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RAND'S DIGITAL COMPUTER EFFORT

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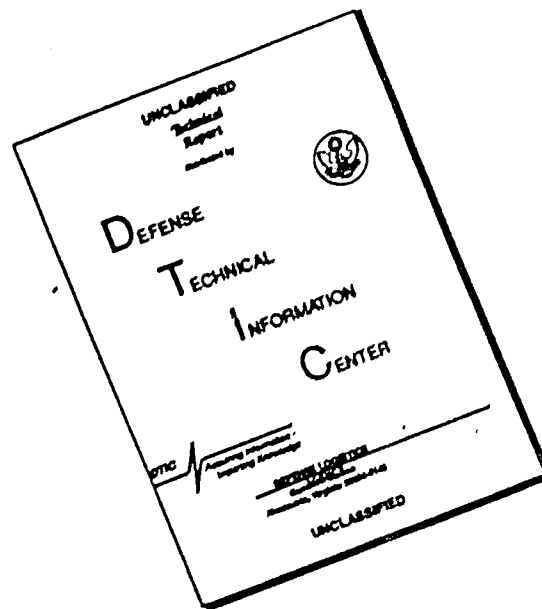
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RAND'S DIGITAL COMPUTER EFFORT

WILLIAM F. GUNNING

The RAND Corporation, as many of you know, has approached the computing business from the point of view of a user. A large computing effort is necessary in carrying out RAND's contract with the Air Force. Most of this computing, at the present time, is being done on IBM equipment. We have sent crews out to work on machines all over the country. There is almost always some RAND contingent with a problem on one of the large digital machines in the East.

Our IBM installation consists presently of three Model II CPC's and two 604's. These equipments are run on a three-shift basis.

For some of the problems that we must solve, analog equipment seems to be preferable. We have a medium sized modified REAC installation which includes some quasi-digital features so it is presentable at this meeting. It has an IBM type plug board which controls every component in the machine. All problem preparation is done away from the machine. There is an operator's console at which the operator can sit down and run the machine in a convenient way. It contains an analog-to-digital device which allows results to be punched on IBM cards and also facilitates the setting of scale factor potentiometers at the beginning of the problem and for successive runs. It includes a fair number of decision elements which allow the computing program to be changed

automatically as the results become available to the computer. These are, in more definite terms, high-gain amplifiers which operate relays connected to the plug board.

The rate of growth of computing effort at RAND has been such that it became clear that we could not hope to handle the expected load by simply enlarging our standard IBM installation. A large general purpose high speed machine was needed. About two years ago, a national tour was made and it was decided to go along with several other organizations and produce a copy, or rather a modified version as they have all turned out, of the IAS machine. I think that almost everybody here is aware of the principle features of that machine. It will only be necessary to describe the deviations as they developed in the last year and a half or so. Some items are not deviations any more, and are things to be found in the ORDVAC and other siblings of the original at Princeton.

The first of these is IBM card input-output. We plan to use a collator as an input device. The code can call for a card from either or both of the two feeds. The output will be done on a standard IBM punch. All information will be considered by the machine as 12 binary words per card. Decimal information must be handled by a loading and conversion routine similar to that used by the IBM 701 computer. It turns out that the input rate can be as high as 96 words per second since the collator feeds four cards per second in both feeds.

Our machine has the logical control and gates for a magnetic drum built into the main frame. The read and write amplifiers are under development. The drum is to be divided logically into two

sections, one of which can communicate with card machinery independently. The other section will be communicating with the machine. The two sections are inter-changed between problems.

The drum order is organized in a way that allows an arbitrary block of information to be transferred from high-speed storage to the drum and vice versa. A standard half word order calls for a drum transfer and specifies the first electrostatic address. A special word in MQ (the multiplier quotient register) specifies the first and last drum addresses.

The machine will have an operator's console. The design is the result of a seminar that has run for some time and was attended by RAND people who have had experience on, I think, seven members of the AC family and have brought back their feelings after using these various machines. We hope to have an eclectic console.

The operator will see a display, in octal, of the contents of either the accumulator or the multiplier quotient register. This will occur whenever the machine is halted or when called for in the code when the machine is computing automatically. A relay storage and encoding register holds the information and allows the machine to proceed. Coded requests for display that occur too frequently are ignored.

There will be an arrangement similar to the EDVAC "halt at address A" device in which an address may be set on the console. The machine will halt when this point in the code is reached. A word may be entered into any register from the console. There will be indications of why the machine has stopped, such as, "stopped from a regular halt order, stopped because there has been an overflow or, reached the stop address". None of the buttons or

switches (except halt) will be effective while the machine is computing automatically.

The order list has been changed slightly. We have a partial substitution order for words being sent to the memory. There is an extract or logical product order. There is an overflow indicator for addition and subtraction. This operation may be used to halt the computer at the option of the operator. A division order has been provided which will accommodate a double length numerator; that is, a 78 binary digit numerator. Either sign can be used in multiplication and division.

Most of the things discussed so far have been points that the user would be aware of. There are some engineering modifications that may be of some interest but before mentioning them, I would like to pay tribute to the work done by the people at the Institute for Advanced Study. Many of us who are in the course of making copies of the IAS machine have a tendency to emphasize our deviations and forget the tremendous debt that we owe Julian Bigelow and others at the Institute. I think that the fact that so many of us have been able to make an arithmetic unit that works when first plugged in and which requires no fussing, is proof enough of the fundamental contribution that they have made. With this apology, I should like to mention some of the changes that we have made in the machine and its surrounding equipment.

First of all, we have spent a considerable amount of money and effort to assure adequate cooling. One of the bug-a-boos is getting the heat out of these machines. We have a closed cycle arrangement which assures plenty of dry, clean air. The same air

is used repeatedly with a heat exchanger and filters in the circuit.

The other deviation that is of principal engineering importance is in the memory. About a year and a half ago, we made a second tour and attempted to assess the status of Williams memories in the various machines throughout the country. At that time it was our judgment that the limited amount of effort we could put in further development of Williams memory systems -- and at that time I think all were agreed that they needed further development -- would not have contributed significantly to reaching a good solution for this kind of memory. Consequently, we decided for this and other reasons to use a memory based on the RCA selectron tube. This tube, as you probably remember, was primarily developed in connection with the IAS machine. It is particularly well suited to a high-speed parallel machine. We now have a memory designed and under construction, using either 40 or 80 selectrons, which means either a 256 or 512 word high-speed memory. The option is based on the fact that the selectron is an expensive device and not only the first cost but the running costs of the machine must be considered. Consequently, we are interested in developing a substitute memory system. Even if the life of the tubes is several thousand hours or even 10,000 hours, the cost of running the machine with selectrons will be quite high.

The contender we like best is the magnetic core. We have already started on that work as you can see (indicating).

The frame of the machine has been considerably changed from that of the Princeton prototype. We have enlarged the frame such

that there are about two times as many tube sockets. Even now, with the machine including the drum equipment, we have of the order of 500 spare tube sockets. This is a comfortable position to be in.

The heater circuits have been isolated into groups of about 12 each such that we may make marginal checks on heater-cathode leakage without interfering with normal machine operation.

The control contains only one counter instead of two. This counter takes care of shift counting, counting of successive addresses in the high speed memory during a drum order, and order counting.

The maintenance console will include an indication of the state of every toggle in the machine. Alarm fuses are used in profusion. There is an arrangement to monitor all the principal voltages in the machine and the operation of the refrigeration equipment.

We have installed in our new building, which we hope to move into in about a week, a large motor-generator set to isolate us from the severe line transients that exist in Southern California. We also have a small standby unit.

The future activities of the RAND group in the engineering aspects of computing are sure to be somewhat varied. It seems appropriate that RAND maintain a small corps of engineers that are well versed in the technical aspects of both analog and digital computing to carry out its prime purpose. When this machine is operating and we can reduce the efforts on its construction and development, there will probably be a continuing hardware develop-

ment effort at perhaps 50 per cent of the present level.

CHAIRMAN HESTENES: Are there any questions of the RAND operation?

DR. EDWARD TELLER: Is it proper to ask what is your time schedule?

MR. GUNNING: The von Neumann constant that we are using is approximately ten months. We qualify this further by saying that the definition of completed that we are using is that the machine will be capable of doing a prime number problem for one hour. (Laughter). It will not necessarily have the drum or console attached.

DR. TELLER: Thank you.

CHAIRMAN HESTENES: Any other questions? I think it is time to go ahead with Dr. Brown's discussion.